Emission from interstellar gas and dust in M 31

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ABSTRACT. We present preliminary results of a comparison of the spatial distributions of 100 μm, H I and CO emission in M 31. Using a scatter diagram of 100 μm intensity versus H I column density, we have derived an upper limit to the *molecular* gas column density. We have compared these values with the velocity-integrated CO intensity to find an upper limit to the CO-to-H_2 conversion factor in the ring of M 31 of $5\,10^{20}$ mol cm^{-2} [K km s^{-1}]$^{-1}$.

Although a wealth of data exists on the interstellar medium of M 31, no detailed comparison of the spatial distributions of the different constituents of the ISM has yet been made. In our comparison we have used the IRAS data as presented by Walterbos and Schwering (1987), the Bonn H I survey of Cram, Roberts and Whitehurst (1980) and results of the CfA CO survey (Dame *et al.*, 1990). In the CO survey the same half-beamwidth grid (spacing 4.′5) as in the H I observations was used, fully sampling the disk of M 31 out to a radius of 15 kpc. Both the CO and H I data were observed with an angular resolution of $\sim$ 8.′8. The 100 μm map has been smoothed to this resolution and regridded to the 4.′5 sampling grid.

In Figure 1a we show the I_{100} versus N(H I) scatter diagram. A number of different sections in the diagram can be defined that correspond to distinct, connected regions in M 31; a rough sketch of these sections is shown in Figure 1b. The section labelled 'inner' corresponds to inner part of M 31, containing the bright infrared nucleus (radius $R \lesssim 6$ kpc), the 'ring' section corresponds to the well-known Population I ring ($6 \lesssim R \lesssim 13$ kpc) and 'outer' to $R \gtrsim 13$ kpc. In the 'outer' section, the many positions with little or no molecular or ionized gas can be used to calibrate the relation between the *total* gas column density N(H) and I_{100}; a linear fit to such points, which form a well-defined upper bound to N(H I) for a given I_{100} in Figure 1a, is approximately given by $N(\mathrm{H\,I}) = 6.3\sqrt{I_{100}}$, with N(H I) in units of 10^{20} at cm^{-2} and I_{100} in MJy sr^{-1}. If we assume that there are no basic physical differences between the outer parts of M 31 and the ring and that this fit also holds in the ring, where virtually all of the molecular emission is concentrated, we can find the molecular

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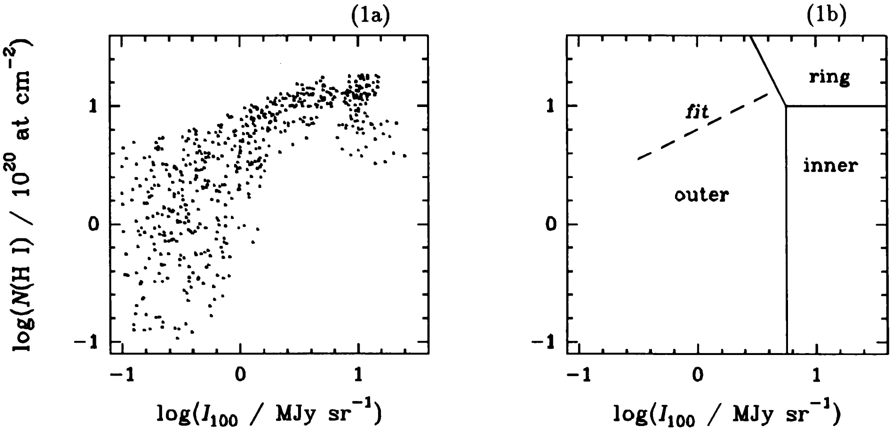

Fig. 1a. Scatter diagram of $\log(I_{100}$ / $\mathrm{MJy\,sr^{-1}})$ versus $\log(N(\mathrm{H\,I})$ / $10^{20}\,\mathrm{at\,cm^{-2}})$.
Fig. 1b. The subdivision of the diagram in three sections and the $N(\mathrm{H\,I})$ fit (see text for details).

gas column density $N(H_2)$ by subtracting the observed atomic column density from the derived value for the total gas column density: $2\,N(H_2)^{fit} = N(\mathrm{H})^{fit} - N(\mathrm{H\,I})^{obs}$.

Using the CO map of Dame *et al.* (1990), we have compared the observed values of W_{CO} with the upper limits for $N(H_2)$ described earlier. This gives us an upper limit to the CO-to-H_2 conversion factor X in M 31. A plot of this X with radius is shown in Figure 2. We find that the global upper limit to the X-factor in the ring is of order 5. The standard value of X in our Galaxy is 2.3 (Strong *et al.*, 1988).

Our value of X gives us an upper limit to the total molecular mass in M 31 of roughly $7\,10^8\,\mathrm{M}_\odot$, or about a fifth of the total atomic gas mass ($3.9\,10^9\,\mathrm{M}_\odot$, Cram, Roberts and Whitehurst, 1980).

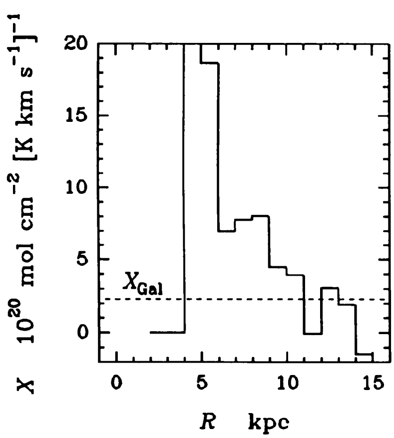

Fig. 2. Average values of X in 1 kpc bins.

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